

DP 1898 DE - NJ



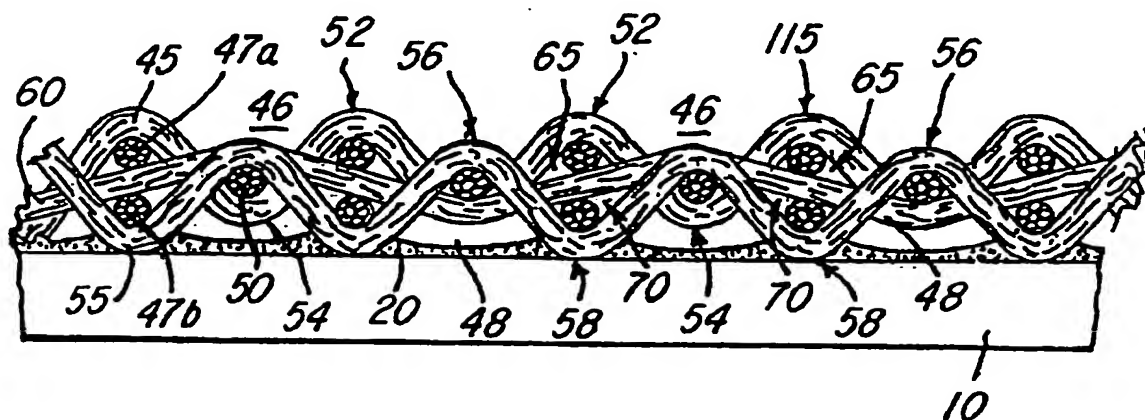
PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification 6 : F16D 13/72, 65/78, 69/02, B32B 7/00, 31/00, D03D 15/00</p>	<p>A1</p>	<p>(11) International Publication Number: <b>WO 96/10701</b> (43) International Publication Date: 11 April 1996 (11.04.96)</p>
<p>(21) International Application Number: PCT/US95/12489 (22) International Filing Date: 29 September 1995 (29.09.95) (30) Priority Data: 08/316,204 30 September 1994 (30.09.94) US (71)(72) Applicant and Inventor: NELS, Terry, E. [US/US]; 2973 Southfield Drive, Beavercreek, OH 45434 (US). (74) Agents: JENKINS, Matthew, R. et al.; Jacox, Meckstroth &amp; Jenkins, 2310 Far Hills Building, Dayton, OH 45419-1575 (US).</p>		<p>(81) Designated States: BR, CA, JP, MX, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</p>

(54) Title: FABRIC ARRANGEMENT AND METHOD FOR CONTROLLING FLUID FLOW



(57) Abstract

In accordance with one aspect of the present invention, a material (115) for an element of a power transmission-absorption assembly and the method and making such material (115) is disclosed. The material (115) comprises a plurality of first yarns (45, 55, 60) woven with a plurality of second yarns (47a, 47b, 50) to form a pre-selected channel configuration (46, 48, 65, 70) to permit flow of a cooling medium thereacross or therethrough.

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

-1-

**FABRIC ARRANGEMENT AND METHOD  
FOR CONTROLLING FLUID FLOW**

**BACKGROUND OF THE INVENTION**

1.       **Field of the Invention**

The present invention relates to a fabric arrangement and method for controlling fluid flow and, more particularly, to a fabric arrangement and method for  
5 controlling fluid flow which may be utilized with friction elements.

2.       **Description of Related Art**

In clutches, brakes, automatic transmissions, limited slip differentials, hoists and similar friction  
10 power transmission and energy absorption devices, there is generally provided one or more sets of cooperating members, in which one of the cooperating members drives the other. It is not uncommon for these cooperating members to move in a cooling medium or liquid, which is  
15 generally some type of lubricating oil, and frequently the oil is force circulated about and between the engaging surfaces of the cooperating members so as to continuously lubricate and cool them. In order to accomplish circulation of the cooling medium within  
20 blocker rings, clutch plates, transmission bands and the like, the prior art has provided grooves or slots directly in the engaging surfaces of one or both of the cooperating members or in friction material affixed thereto. For example, such a friction material may be a  
25 brass coating or a paper liner as seen in U.S. Patent 4,267,912 to Bauer et al., U.S. Patent 4,878,282 to Bauer, and U.S. Patent 4,260,047 to Nels.

-2-

Forming grooves within the friction material of cooperating members not only adds complexity to the manufacture of such friction material and the power transmission-absorption device, but also is limited in its ability to circulate cooling medium therethrough. In order to reduce or eliminate the hydrodynamic friction stemming from oil or cooling medium lying on the surface of the friction material engaging the driving member, an improved friction material for circulating the cooling medium is required, especially one which may be varied according to desired parameters.

Prior art friction materials also include certain pyrolytic carbon friction materials as seen in U.S. Patent 4,700,823 to Winckler and U.S. Patent 4,291,794 to Bauer. In such friction material, a meshed cloth substrate formed of carbon fibers is provided with a coating of carbon or other material being deposited on the fibers by chemical vapor deposition. This type of friction material has the characteristic of a relatively open mesh which allows ready penetration by an adhesive for improved bonding, as well as a certain degree of porosity therethrough. However, as pointed out in the '794 patent, grooving of such material is still provided in order to permit the flow of the cooling fluid between the friction faces of the cooperating members of the power transmission or energy absorption assembly. This type of friction material also does not easily provide highly bonded fibers at a friction surface of the material nor does it achieve a highly controlled texture as needed. Moreover, it has been found that such friction material is difficult to compress to a desired thickness, such as during the process of bonding it to a member.

-3-

It is also seen that such pyrolytic friction material utilizes as its substrate a plain weave of the type illustrated in Fig. 6, where both the fill and warp yarns of the material contact the cooperating element.

- 5 Such an arrangement leads to increased wear of the friction material due to the effect on the yarns oriented perpendicularly to the direction of motion for the cooperating element. Therefore, an additional desired feature not found in prior art devices is a friction  
10 surface texture which reduces wear on the friction material.

#### SUMMARY OF THE INVENTION

- In accordance with one aspect of the present invention, a material is disclosed having a plurality of  
15 first yarns and a plurality of second yarns woven with the plurality of first yarns to form a predetermined arrangement in order to control fluid flow.

- A second aspect of the present invention is a friction power absorption or power transmission assembly  
20 of the type having means for changing the relative position between a friction material and an opposing surface material from a position of complete engagement to a position of complete disengagement, the assembly including a first member, a second opposing member, a  
25 friction facing material affixed to one of the first and second members, the friction facing material being a woven fabric having a plurality of first yarns positioned in substantially parallel relationship to each other and a plurality of second yarns woven in serpentine fashion  
30 over and under the first yarns to form a texture having a plurality of plateaus and valleys, wherein only the plateaus of the woven fabric engage the other of the

-4-

members, and means for introducing a liquid cooling medium between the first and second members.

Further, a method of making a friction facing material for use in a power absorption-transmission assembly is disclosed involving the steps of weaving a plurality of yarns in a predetermined pattern so as to form a woven fabric having a texture with a plurality of plateaus and valleys therein, fixing the woven fabric yarns in position, and providing an adhesive to the woven fabric.

Accordingly, one objective of the present invention is to provide a friction facing material for use with cooperating members of a power transmission-absorption device which is able to circulate cooling medium therethrough without the need for machining additional grooves or slots.

A further objective of the present invention is to provide a friction facing material for use with cooperating members of a power transmission-absorption device which can be oriented with respect to the direction of movement between the cooperating members so as to reduce wear and spin loss thereof.

Yet another objective of the present invention is to provide a friction facing material for use with cooperating members of a power transmission-absorption device which can be woven so as to include flow channels of desired size and orientation.

#### BRIEF DESCRIPTION OF THE DRAWING

While the specification concludes with claims particularly pointing out and distinctly claiming the present invention, it is believed that the same will be better understood from the following description taken in

-5-

conjunction with the accompanying drawing in which:

Fig. 1 is a front view of a blocker ring having a friction facing material bonded thereon in accordance with the present invention;

5 Fig. 2 is an enlarged, partial cross-sectional view of the blocker ring in Fig. 1;

Fig. 3 is an exploded perspective view of the blocker ring depicted in Figs. 1 and 2 with its cooperating elements in a typical power transmission-absorption assembly;

Fig. 4A, which is shown on the same sheet as Fig. 2, is an enlarged, diagrammatic side view of the friction facing material of Figs. 1-3 prior to bonding;

15 Fig. 4B, which is shown on the same sheet as Fig. 2, is a partial, magnified view of a single yarn in the friction facing material of Fig. 4A;

Fig. 4C, which is shown on the same sheet as Fig. 2, is a partial, diagrammatic side view of the channels defined in the friction facing material of Fig. 4A, where the plateaus and low points are depicted in their state after bonding;

20 Fig. 5 is a photograph of the friction facing material depicted in Fig. 4A;

Fig. 6 is a photograph of a prior art friction facing material having a plain weave;

25 Fig. 7 is a diagrammatic depiction of several exemplary weave styles which may be employed in the friction facing material of the present invention;

Fig. 8 is a diagrammatic depiction of the friction facing material of the present invention being circumferentially arranged as non-interlocking arcuate segments on a clutch plate;

30 Fig. 9 is a diagrammatic depiction of the

friction facing material of the present invention being circumferentially arranged as interlocking arcuate segments on a clutch plate;

Fig. 10 is a diagrammatic depiction of the  
5 friction facing material of the present invention being arranged as a plain cut full ring on a clutch plate;

Fig. 11 is a diagrammatic depiction of the friction facing material of the present invention being arranged as an edge wound full ring on a clutch plate;

10 Fig. 12A is a diagrammatic depiction of a strip of the friction facing material of the present invention, where a plurality of notches have been formed therein;

Fig. 12B is a diagrammatic depiction of the strip of friction facing material shown in Fig. 12A  
15 arranged on a clutch plate;

Fig. 13A is a diagrammatic depiction of a strip of friction facing material of the present invention, where a plurality of lances have been formed therein;

20 Fig. 13B is a diagrammatic depiction of the strip of friction facing material shown in Fig. 13A arranged on a clutch plate;

Fig. 14 is a diagrammatic depiction of friction facing materials having different weave patterns, including some with several layers of different weave  
25 patterns, being circumferentially arranged as non-interlocking arcuate segments on a clutch plate;

Fig. 15 depicts an enlarged, diagrammatic side view of an alternate embodiment for the friction facing material of the present invention;

30 Fig. 16 is an enlarged diagrammatic side view of a third embodiment of the friction facing material of the present invention; and



-7-

Fig. 17 is an enlarged diagrammatic side view of a fourth embodiment of the friction facing material of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

5 Referring now to the drawing in detail, wherein identical numerals indicate the same elements throughout the figures, Fig. 1 depicts a blocker ring 10 including a friction facing material 15 affixed to an inner annular wall 12 thereof in conjunction with the present  
10 invention. It will be understood that blocker ring 10 is one element of a power transmission or absorption assembly such as that utilized in clutches, brakes, automatic transmissions, limited slip differentials, hoists and other similar friction power transmission and  
15 energy absorption devices. One example of the environment in which blocker ring 10 may be utilized is disclosed in U.S. Patent 4,732,247 to Frost, which is hereby incorporated by reference. While blocker ring 10 and friction facing material 15 discussed herein may be  
20 utilized with such friction power transmission and energy absorption devices, it will be understood that friction facing material 15 of the present invention is not limited to such specific devices. For example, friction facing material 15 may be utilized in other friction  
25 devices such as clutch plates, torque converter clutches, and transmission bands. Moreover, it is contemplated that the material of the present invention could be utilized in other devices where the control of fluid flow is required, such as gaskets, filters, nozzles, and the  
30 like.

As seen in Fig. 1, blocker ring 10 includes three raised lugs 14 equally spaced at 120° intervals

-8-

around blocker ring 10. Lugs 14 may be nested within associated hub notches of another member 17 of the assembly (not shown). As best seen in Fig. 3, blocker ring 10 also has a toothed or splined surface 16 formed  
5 on the outer circumference thereof which is engagable with member 17 of the power transmission-absorption assembly and thereby able to clock or rotate member 17 in accordance with a cooperating friction element 18 causing movement along inner annular wall 12. As best seen in  
10 Figs. 1 and 2, friction facing material 15 of the present invention is affixed to inner annular wall 12 of blocker ring 10 by means of a layer of adhesive 20, such as nitrile phenolic adhesive. It will be understood that cooperating friction element 18 (see Fig. 3) is movable  
15 along a longitudinal axis 19 in order to engage and disengage blocker ring 10.

Fig. 4A depicts a diagrammatic side view of friction facing material 15 in its initial state, which includes a plurality of substantially linear fill yarns  
20 25 arranged substantially parallel to each other. A plurality of substantially parallel warp yarns 30 shown in a sinusoidal side view in Fig. 4A are woven with fill yarns 25 in a serpentine fashion (i.e., over and under adjacent fill yarns 25) to form a series of high points  
25 32 (known as "plateaus") and a series of low points 34 (known as "adhesion points"). Positioned between each warp yarn 30 is a second set of warp yarns 31, which also are woven in serpentine fashion with fill yarns 25 to form a series of plateaus 33 and a series of adhesion  
30 points 35. However, in order to maintain the construction of friction facing material 15, warp yarns 31 are out of phase with warp yarns 30 so that plateaus 32 of warp yarns 30 are opposite adhesion points 35 of

-9-

warp yarns 31 and adhesion points 34 of warp yarns 30 are opposite plateaus 33 of warp yarns 31. By weaving warp yarns 30 and 31 with fill yarns 25 in this way, a plurality of upper channels 36 and 37 (known as "valleys") are formed between adjacent plateaus 32 and adjacent plateaus 33, respectively. Likewise, a plurality of lower channels 38 and 39 may be formed between adjacent adhesion points 34 and adhesion points 35.

Further, as best seen in Fig. 5, fill yarns 25 may be tensioned by a greater amount than warp yarns 30 and 31, which also facilitates defining the formation of upper channels 36 and 37 in a predetermined or desired weave pattern. Because plateaus 32 and 33 of warp yarns 30 and 31 extend above fill yarns 25, it will be understood that only warp yarn surfaces 30a at plateaus 32 and warp yarn surfaces 31a at plateaus 33 (see Fig. 4A) of friction facing material 15 will engage cooperating friction member 18. In order to reduce wear of friction facing material 15, it is preferred that warp yarns 30 and 31 be positioned so that they are aligned substantially parallel to longitudinal axis 19 (see Figs. 3 and 4A) which is also the direction of relative motion between blocker ring 10 and cooperating friction element 18 to reduce wear on friction facing material 15. It is to be noted that some prior art materials provide warp yarns and fill yarns having engaging surfaces at the same level (see Fig. 6). Consequently, at least some of the yarns are oriented substantially perpendicular to the direction of movement between the cooperating friction members. This, in turn, causes increased wear of the material and/or the cooperating friction member. It should also be noted that while warp yarns 30 and 31 are

-10-

shown as being woven with substantially linear fill yarns 25, the warp yarns may be substantially linear and two sets of fill yarns may be woven therewith.

It will also be noted that a layer of adhesive  
5 20 is preferably provided so that it engages only adhesive points 34 and 35 of warp yarns 30 and 31, respectively. In this way, both upper channels 36 and 37 and lower channels 38 and 39 (see Fig. 4A) are able to provide flow paths for cooling medium, such as oil, in  
10 the power transmission-absorption assembly.

As depicted by the side view representation in Fig. 4C, it will be understood that upper channels 36 and 37, as well as lower channels 38 and 39, preferably have tapered sides 41 and 42. An angle  $\phi$  exists between side  
15 walls 41 and 42 and the respective plateaus and adhesion points of warp yarns 30 and 31, with angle  $\phi$  having an angle in the range of 20°-70°, and preferably approximately 45°. By having channels 36-39 formed in this way, exiting of cooling medium therethrough is  
20 facilitated due to the Bernoulli theorem.

Further, it will be seen from Fig. 4C that bonding of friction facing material 15 onto a friction element will have a flattening effect on plateaus 32 and 33 of warp yarns 30 and 31, as well as on low points 34  
25 and 35 thereof.

Fill yarns 25 and warp yarns 30 and 31 preferably are carbonized both before and after weaving, with friction facing material 15 preferably being saturated with resin and cured to further fix fill yarns  
30 25 and warp yarns 30 and 31 in the predetermined or desired weave pattern. Even so, friction facing material 15 will generally retain interconnection between upper channels 36 and upper channels 37, while maintaining

-11-

desired strength characteristics, provided the resin applied thereto is maintained within a range of about 35-50% of friction facing material 15.

With regard to the construction of fill yarns 5 25 and warp yarns 30 and 31, it has been found that at least nine (9) twists per inch provide suitable definition of the texture for friction facing material 15. In this way, upper channels 36 and 37 and lower channels 38 and 39 thereof become more distinct, thereby 10 increasing the ability of cooling medium to flow therethrough. It will be understood that in order for fill yarns 25 and warp yarns 30 and 31 to have nine twists per inch, an angle  $\theta$  existing between each fibril 26 and a longitudinal axis 28 (see Fig. 4B), is 15 approximately  $27^\circ$  for a yarn having a diameter of .018 inches. Because there is a direct relationship between angle  $\theta$  and the twists per inch of the yarn, it will be understood that angle  $\theta$  increases as the twists per inch of the yarn increases. Thus, an angle  $\theta$  of  $27^\circ$  or 20 greater for fibrils 26 of each yarn will consequently provide the desired definition of the texture for friction facing material 15, as well as a column strength that will desirably protect against compressive loads.

It will also be understood that during the yarn 25 manufacturing, the fibrils 26 of warp yarns 30 and 31 will fracture at various points due to the stretching thereof while in a carbonized state. Accordingly, such fibrils 26 may have a length of approximately  $1/4$  to  $1/2$  inch between fracture points 27 (see Fig. 4C). This 30 construction permits heat to be conducted through the length of a yarn by means of fibrils 26 to fracture points 27, whereupon the heat can then be transmitted to the cooling medium contained within lower channels 38 and

-12-

39.

Another preference of the embodiment herein described is to weave warp yarns 30 and 31 with fill yarns 25 so that plateaus 32 and 33 of warp yarns 30 and 31 have a maximum surface area across friction facing material 15. One manner of increasing such surface area is to weave warp yarns 30 and 31 over more adjacent fill yarns 25 than the number of adjacent fill yarns 25 they are woven under. For example, warp yarns 30 and 31 may be woven over at least two adjacent fill yarns 25 and under at least one fewer adjacent fill yarns 25 alternatively to create a satin weave fabric (see, e.g., the crowfoot satin weave of Fig. 7, where the dark portions represent plateaus 32 and the white portions represent valleys 36 and 37 therebetween). This type of weave creates rectangular plateaus of increased surface area for contacting a cooperating friction element, which is particularly useful in a dry friction element such as brake and clutch facings, whereby improvement in both wear resistance and thermal conductivity is achieved.

It will be understood, however, that any number of weaves may be utilized or provided with friction facing material 15, including the exemplary weaves shown in Fig. 7 (e.g., plain, crowfoot satin, 2 x 2 basket, 5 HS, 8 HS, Leno, 2/2 twill, 2/1 twill, non-crimp,  $\pm 45^\circ$  plain,  $\pm 45^\circ$  8 HS, and  $\pm 45^\circ$  crowfoot satin). In fact, such weaves may be selected, designed or utilized to control the size, number, and orientation of upper channels 36 and 37 and lower channels 38 and 39, and consequently the flow paths across friction facing material 15. Accordingly, the amount and velocity of oil or other cooling medium forced across friction facing material 15 can be controlled.

-13-

While a preferred material for friction facing material 15 is carbon, it will be understood that fiberglass, silicone carbide, copper, ceramic, Kevlar, asbestos, or any other material having the required strength, temperature resistance, friction characteristics, and processibility for the intended application may be utilized.

It will also be seen from Figs. 15 and 16 that the friction facing material of the present invention may have several layers of fill and warp yarns. Such a multi-layered arrangement not only improves the durability of friction facing material 15, but may include internal cooling vents which further enhances the flow of cooling oil or air therein. Specifically, as seen in Fig. 15, friction facing material 115 contains fill yarns in a dual layer--single layer--dual layer alternating arrangement. A first set of warp yarns 45 is woven over dual layer fill yarns 47a and 47b and under single layer fill yarns 50 in serpentine fashion so as to form a plurality of high points or plateaus 52 and low points 54. A second set of warp yarns 55, which is positioned between adjacent first warp yarns 45, is woven in serpentine fashion under dual layer fill yarns 47a and 47b and over single layer fill yarns 50 (i.e., substantially 90° out of phase with first warp yarns 45) to form high points or plateaus 56 and low points or adhesion points 58 which are opposite low points 54 and plateaus 52, respectively. A third set of warp yarns 60 is woven between dual layer fill yarns 47a and 47b and alternatively over and under single layer fill yarns 50, and is preferably positioned between each adjacent first and second warp yarn 45 and 55, respectively. Accordingly, a plurality of upper cooling vents 65 and

-14-

lower cooling vents 70 are formed within friction facing material 115. Thus, not only are upper channels 46 between adjacent plateaus 52 of first warp yarns 45 and lower channels 48 between adjacent adhesion points 58 of second warp yarns 55 present for flow of oil discharge thereacross, but internal cooling vents 65 and 70 may also be utilized for the flow of cooling oil or air.

Another embodiment of the friction facing material (designated by the number 215) is depicted in Fig. 16, where the multi-layered material thereof may be provided or weaved to include internal cooling vents 75 of predetermined size and shape. As seen therein, multiple layers of substantially linear fill yarns 77 are arranged in a substantially parallel configuration. It will be seen that two sets of warp yarns 78 and 80 are provided for each layer of fill yarns 77, where first warp yarns 78 and second warp yarns 80 are woven in serpentine fashion with fill yarns 77 but in juxtaposition with respect to each other so that plateaus 82 and 84 and valleys 86 and 88 thereof are approximately 90° out of phase. In order to form a relatively large internal cooling or fluid flow vent or channel 75, certain specified fill strands (such as 77A and 77B shown in phantom in Fig. 16) are omitted from various locations and layers to facilitate providing the cooling vent or channel 75 having a predetermined configuration. Accordingly, first warp yarns 78A, 78B and second warp yarns 80A, 80B normally woven with such omitted fill yarns 77A and 77B may be woven with fill yarns 77 of a different layer (e.g., top and bottom fill yarn layers  $L_1$  and  $L_4$  as shown in Fig. 16). While warp yarns 78A, 78B, 80A, and 80B are shown as being woven with top and bottom layers  $L_1$  and  $L_4$  of fill yarns 77, thereby providing the



-15-

greatest available height dimension  $h$  for internal cooling vent 75, it will be understood that fill yarns 77 for any given layer may be omitted to provide internal cooling vents 75 of greater or lesser height  $h$  so long as at least two layers of fill strands 77 remain for weaving purposes. Further, any number of adjacent fill yarns 77 may be omitted to give internal cooling vent 75 a greater or lesser width. To simplify weaving, it is preferred that internal cooling vents or channels 75 be of the same size and shape and repeat in symmetric fashion; however, internal cooling vents 75 may be dissimilar and asymmetric according to the needs of a specific application.

Yet another alternative embodiment for the friction facing material of the present invention, identified by the numeral 315, is depicted in Fig. 17, where only a plurality of substantially parallel yarns (indicated as fill yarns 25 but also may be warp yarns) is provided in conjunction with a layer of scrim 21 on blocker ring 10. In this arrangement, it is preferred that scrim 21 be saturated with adhesive or resin (although separate adhesive layers 20a and 20b may be utilized), whereby yarns 25 may be attached thereto and scrim 21 may be attached to inner annular wall 12 of blocker ring 10. It will be understood that a plurality of substantially linear channels 23 will be formed between adjacent fill yarns 25, which may be utilized to conduct lubricating/cooling fluid across friction facing material 315. Depending on a given application, it will be understood that channels 23 can be oriented on a friction element so as to be at an angle between  $0^\circ$  and  $90^\circ$  to the sliding surface of the friction element.

While friction facing material 15 has been

-16-

depicted as being positioned on inner annular wall 12 of blocker ring 10, it could just have easily been positioned upon an outer annular wall 22 of cooperating friction element 18 (see Fig. 3). Moreover, as seen in  
5 Figs. 8-11, 12B, 13B, and 14, friction facing material 15 may be utilized with other types of friction members such as a clutch plate 90, where it is circumferentially positioned around a front or rear surface 92. There are several ways for friction facing material 15 to be  
10 positioned on clutch plate surface 92, such as non-interlocking arcuate segments 94 (see Fig. 8). This arrangement forms channels 95 between each arcuate segment 94 which may permit a greater flow of cooling oil than channels 36 and 37, depending on the width of  
15 channels 95. Alternatively, friction facing material 15 may include interlocking arcuate segments 96 to form a complete ring around clutch plate surface 92, as seen in Fig. 9 and disclosed in U.S. Patent 4,260,047 to Nels which is hereby incorporated by reference. As seen  
20 therein, each interlocking segment 96 includes a male extension 98 at a first end and a female receptacle 99 at a second end which may be mated together. The advantages of utilizing arcuate segments 94 or 96 for a ring-shaped object like clutch plate surface 92 are that it saves  
25 material during the blanking process and allows the yarn cooperating with the mating surface to remain approximately parallel with the direction of engagement and disengagement between the friction elements. Nevertheless, friction facing material 15 may be plain  
30 cut (or blanked) as a full ring 100 (see Fig. 10).

Alternatively, a strip of friction facing material 15 may be formed into a flattened hoop 102 so that it may be edge wound about clutch plate surface 92 as seen in Fig. 11. Such a strip of friction facing  
35 material 15 preferably includes a single male extension

-17-

104 at one end and a single female receptacle 105 at the other end so that each end of hoop 102 may be properly mated.

As seen in Figs. 12A and 13A, strips 106 and 107 of friction facing material 15 may have notches 108 or lances 109 formed therein. Then, strips 106 and 107 may be positioned on clutch plate surface 92 as seen in Figs. 12B and 13B, whereby notches 108 are brought together or lances 109 are pulled apart. In either case, strips 106 and 107 form a multi-sided shape that is sized to fit on clutch plate surface 92.

As shown in Fig. 14, it will be understood that friction facing material of different weaves may be utilized together. There, friction facing material 110, 111, and 112 of various weaves are attached to surface 92 of clutch plate 90 in the form of non-interlocking arcuate segments. It will be seen that friction facing material 110 has the greatest number of flow paths as defined by upper channels 36 and 37 (indicated by white areas 116), thereby permitting the greatest amount of cooling flow. Friction facing material 111 has some flow paths, but fewer than friction facing material 110. Finally, friction facing material 112 has no leakage paths. Thus, depending on the desired amount of cooling medium flow or leakage for a particular area, the friction facing material can be tailored thereto. This may be taken a step further, wherein friction facing material 110, 111, and 112 of different weaves may be radially aligned in several layers as shown in Fig. 14. In this way, complete control of the flow characteristics for a given application may be controlled solely by the weave and arrangement of the friction facing material.

With respect to the method of making friction facing material 15, it will be understood that fill yarns 25 and warp yarns 30 and 31 preferably are initially

-18-

carbonized in a high temperature oven. Thereafter, fill  
yarns 25 and warp yarns 30 and 31 are woven in a  
designated pattern for the particular application so that  
channels 36, 37, 38 and 39, and possibly cooling vents  
5 65, 70 or 75, are formed to provide the requisite flow  
paths. In order to fix or lock the woven pattern of fill  
yarns 25 and warp yarns 30 and 31, friction facing  
material 15 is then preferably carbonized again in a high  
temperature oven. To further enhance the locking  
10 process, friction facing material 15 preferably is  
saturated with a resin, such as a phenolic resin, and  
cured at an appropriate amount initially in an oven and  
subsequently at an appropriate amount during the bonding  
process described hereinafter.

15       Once the above steps have been accomplished,  
adhesive 20 is then applied to one surface of the  
saturated fabric, such as by lamination. Friction facing  
material 15 is then ready for blanking, where either  
arcuate segments, whole rings, or strips are cut from the  
20 rolls of material. Lastly, friction facing material 15  
is bonded to a desired friction element, such as blocker  
ring 10 or clutch plate 90. It has been found that a  
punch-die arrangement works well to press friction facing  
material 15 into place on blocker ring 10. For example,  
25 the punch may provide pressure in the range of 50-800  
lbs. per square inch for approximately 40-100 seconds.  
In order to prevent adhesive 20 and phenolic resin from  
wicking into friction facing material 15 during this  
process, since adhesive 20 will tend to be attracted to  
30 the element having a higher temperature, a temperature  
differential preferably is established between the punch  
and the die (e.g., the die preferably having a  
temperature of approximately 550° F and the punch having  
an initial temperature of approximately 250° F increasing  
35 to approximately 400° F during the bond cycle as heat

-19-

moves from the die through the ring adhesive layer, and friction facing material into the punch).

Having shown and described the preferred embodiments of the present invention, wherein an  
5 inventive friction facing material, the method of making the friction facing material, and a friction element including the friction facing material thereon have been disclosed, it will be understood that further adaptations thereof may be accomplished by appropriate modifications  
10 by one of ordinary skill in the art without departing from the scope of the invention. In particular, while the embodiments of the inventive friction facing material have been described herein as preferably including warp yarns weaving with a plurality of substantially linear  
15 fill yarns, the opposite thereof is also contemplated (i.e., where fill yarns may be woven with a plurality of substantially linear warp yarns). Further, the specific weaves and materials disclosed herein are also preferred embodiments, since the yarns may also be braided, but  
20 should not be deemed limiting on the intent of the present invention.

It should also be appreciated that the invention could be applied to a wet or dry environment where the control of fluid flow is required, and the  
25 channels defined by the predetermined yarn arrangement may be used to channel heating or cooling fluids, including gases and liquids.

What is claimed is:

-20-

1. A friction facing material for use in power absorption-transmission assemblies of the type adapted to be operated with a lubricating medium having at least one set of cooperating friction members, means for moving the  
5 friction members into and out of operable engagement, and means for selectively introducing a liquid lubricating medium between said cooperating friction members, said friction facing material being affixed to at least one of said cooperating friction members, comprising:
  - 10 (a) a plurality of first yarns positioned in substantially parallel relationship to each other; and
  - (b) a plurality of second yarns woven over and under said first yarns to form a texture  
15 having a plurality of plateaus and low points;wherein only said plateaus of said second yarns engage the other of said cooperating friction members.
2. The friction facing material of claim 1, wherein said second yarns are oriented substantially parallel to the direction of movement of said cooperating friction members.
3. The friction facing material of claim 1, wherein said first yarns are tensioned greater than said second yarns.
4. The friction facing material of claim 1, further comprising a plurality of upper channels defined between adjacent plateaus and a plurality of lower channels defined between adjacent low points.
5. The friction facing material of claim 4, wherein said low points are interconnected.

-21-

6. The friction facing material of claim 4,  
wherein said upper and lower channels are configured in  
such manner as to control the amount and speed of cooling  
medium flow across said material during engagement of  
5 said cooperating members.
7. The friction facing material of claim 4,  
wherein said upper channels have tapered side walls.
8. The friction facing material of claim 1,  
wherein said first and second yarns have at least 9  
twists per inch.
9. The friction facing material of claim 1,  
wherein said second yarns are woven over a plurality of  
adjacent first yarns and under at least one less of said  
first yarns in alternating fashion, wherein a surface  
5 area of said plateaus is maximized.
10. The friction facing material of claim 1,  
wherein said first yarns are substantially linear.
11. The friction facing material of claim 1,  
wherein an angle between a longitudinal axis for each of  
said first and second yarns and each twist of said yarns  
relative thereto is 27° or more.
12. The friction facing material of claim 1,  
wherein said material is saturated with resin to fix said  
first and second yarns in position.
13. The friction facing material of claim 1,  
wherein said first and second yarns are carbonized by  
heat treatment prior to being woven.

-22-

14. The friction facing material of claim 1, said first and second yarns being comprised of a material selected from the group consisting of fiberglass, silicon carbide, copper, ceramic, Kevlar, carbon and asbestos.

15. The friction facing material of claim 1, wherein said first and second yarns are woven in a pattern selected from the group consisting of plain, crowfoot satin, 2 x 2 basket, 5 HS, 8 HS, Leno, 2/2  
5 twill, 2/1 twill, non-crimp,  $\pm 45^\circ$  plain,  $\pm 45^\circ$  8 HS, and  $\pm 45^\circ$  crowfoot satin.

16. The friction facing material of claim 1, wherein said first yarns are fill yarns and said second yarns are warp yarns.

17. The friction facing material of claim 16, wherein said warp yarns include a first set and a second set, said first and second sets of warp yarns being woven with said fill yarns substantially  $90^\circ$  out of phase.

18. The friction facing material of claim 1, wherein said first yarns are warp yarns and said second yarns are fill yarns.

19. The friction facing material of claim 18, wherein said fill yarns include a first set and a second set, said first and second sets of fill yarns being woven with said warp yarns substantially  $90^\circ$  out of phase.

20. The friction facing material of claim 1, wherein said material has a plurality of layers of said first and second yarns.



-23-

21. The friction facing material of claim 20,  
further comprising:

- 5 (a) a plurality of multi-layered first yarns  
and single layered first yarns in  
alternating arrangement;
- 10 (b) a first set of second yarns woven over  
said multi-layered first yarns and under  
said single layered first yarns to form a  
texture having a plurality of plateaus and  
low points; and
- 15 (c) a second set of second yarns positioned  
between adjacent yarns of said first set  
of second yarns, said second set of second  
yarns being woven under said multi-layered  
first yarns and over said single layered  
first yarns to form a texture having a  
plurality of plateaus and low points;
- 20 wherein a plurality of internal cooling vents is formed  
between said plateaus of said first set of second yarns  
and said low points of adjacent yarns of said second set  
of second yarns and between said plateaus of said second  
set of second yarns and low points of adjacent yarns of  
said first set of second yarns.

22. The friction facing material of claim 21,  
further comprising a third set of second yarns woven  
between said multi-layered first yarns and over and under  
said single layered first yarns in alternating fashion.

23. The friction facing material of claim 22,  
wherein upper and lower cooling vents are formed in said  
material as defined by said third set of second yarns.

-24-

24. The friction facing material of claim 20,  
further comprising:

- (a) a plurality of multi-layered first yarns;
- 5 (b) a first set of second yarns woven over and  
under adjacent first yarns for each layer  
of said material; and
- (c) a second set of second yarns positioned  
between adjacent yarns of said first set  
10 of second yarns, said second set of second  
yarns being woven under and over adjacent  
first yarns for each layer of said  
material substantially 90° out of phase  
with said first set of second yarns;
- 15 wherein first yarns of certain layers are omitted to form  
a cooling vent of desired size and shape.

-25-

25. A friction power absorption or power transmission assembly of the type having means for changing the relative position between a friction material and an opposing surface material from a position of complete engagement to a position of complete disengagement, said assembly comprising:

- (a) a first member;
  - (b) a second opposing member;
  - (c) a friction facing material affixed to one of said first and second members, said friction facing material comprising:
    - (1) a plurality of fill yarns positioned in substantially parallel relationship to each other; and
    - (2) a plurality of warp yarns woven over and under said fill yarns to form a texture having a plurality of plateaus and low points;
- wherein only said plateaus of said warp yarns engage the other of said members; and
- (d) means for introducing a cooling medium between said first and second members.

26. The assembly of claim 25, wherein said warp yarns are oriented substantially parallel to the direction of movement of said first and second members.

-26-

27. The assembly of claim 25, further comprising a plurality of upper channels defined between adjacent plateaus and a plurality of lower channels defined between adjacent low points.

28. The assembly of claim 27, wherein said upper channels have tapered side walls.

29. The assembly of claim 25, wherein said fill and warp yarns have at least 9 twists per inch.

30. The assembly of claim 25, wherein said material is saturated with resin to fix said fill and warp yarns in position.

31. The assembly of claim 25, said fill and warp yarns being comprised of a material selected from the group consisting of fiberglass, silicon carbide, copper, rayon, ceramic, Kevlar, carbon and asbestos.

32. The assembly of claim 25, wherein said fill and warp yarns are woven in a pattern selected from the group consisting of plain, crowfoot satin, 2 x 2 basket, 5 HS, 8 HS, Leno, 2/2 twill, 2/1 twill, non-crimp,  $\pm 45^\circ$  plain,  
5  $\pm 45^\circ$  8 HS,  $\pm 45^\circ$  crowfoot satin.

33. The assembly of claim 25, wherein said fill and warp yarns are woven in such manner as to control the amount and speed of cooling medium flow across said material during engagement of said first and second  
5 members.

34. The assembly of claim 25, wherein said material has a plurality of layers of said fill and warp yarns.

-27-

35. The assembly of claim 25, said member having said friction facing material affixed thereto being substantially ring-shaped.

36. The assembly of claim 35, wherein said friction facing material is applied to an inner annular wall of said member.

37. The assembly of claim 35, wherein said friction facing material is affixed to an outer annular wall of said member.

38. The assembly of claim 35, wherein said friction facing material is affixed to a side wall of said member.

39. The assembly of claim 35, wherein said member is a blocker ring.

40. The assembly of claim 35, wherein said member is a clutch plate.

41. The assembly of claim 35, wherein said member is a torque converter clutch pressure plate.

42. The assembly of claim 35, wherein said member is a transmission band.

-28-

43. A method of making a friction facing material for use in a power absorption-transmission assembly, said method comprising the following steps:

- 5 (a) weaving a plurality of yarns in a predetermined pattern so as to form a material having a texture with a plurality of plateaus and low points therein;
- (b) fixing said woven yarns in position; and
- (c) laminating an adhesive to said material.

44. The method of claim 43, further comprising the step of carbonizing said yarns by heat treatment prior to said weaving step.

45. The method of claim 43, wherein said fixing step is performed by carbonizing said material by heat treatment.

46. The method of claim 43, wherein said fixing step is performed by saturating said material in resin.

47. The method of claim 43, wherein said predetermined weave pattern is selected from the group consisting of plain, crowfoot satin, 2 x 2 basket, 5 HS, 8 HS, Leno, 2/2 twill, 2/1 twill, non-crimp,  $\pm 45^\circ$  plain, 5  $\pm 45^\circ$  8 HS,  $\pm 45^\circ$  crowfoot satin.

48. The method of claim 43, further comprising the step of blanking said material into predetermined shapes and sizes.

49. The method of claim 48, wherein said material is blanked in arcuate segments.

-29-

50. The method of claim 49, said arcuate segments including male and female attachments formed at opposite ends thereof, wherein a plurality of said arcuate segments can be connected to form a ring.

51. The method of claim 48, wherein said material is blanked in rings.

52. The method of claim 43, further comprising the step of bonding said material to a friction element of said assembly.

53. The method of claim 52, said bonding step being performed in a punch-die arrangement, wherein said friction element is retained in a die and said friction facing material is pressed onto said friction element by  
5 a punch.

54. The method of claim 53, wherein a temperature difference is provided between said die and said punch.

55. The method of claim 48, wherein said material is blanked into strips and thereafter shaped into a ring.

56. The method of claim 55, wherein said strips have a plurality of spaced notches therein.

57. The method of claim 55, wherein said strips have a plurality of spaced lances therein.

-30-

58. A method of controlling the flow of cooling medium between cooperating friction elements of a power absorption-transmission assembly, comprising the steps of:

- 5 (a) determining a desired pattern of flow paths for said cooling medium flow;  
(b) providing a friction facing material on one of said friction elements having a texture with channels formed therein which  
10 conform to said desired flow path pattern.

59. The method of claim 58, further comprising the step of controlling the orientation of said friction facing material with respect to the direction of movement between said cooperating friction elements.

60. The method of claim 58, said friction facing material including a plurality of fill yarns positioned in substantially parallel relationship to each other and a plurality of warp yarns woven over and under said fill  
5 yarns to form said texture.

61. The method of claim 60, further comprising the step of tensioning said fill yarns greater than said warp yarns.

62. The method of claim 58, said friction facing material having a plurality of layers.

63. The method of claim 62, further comprising the step of providing a plurality of internal cooling vents in said friction facing material.



-31-

64. The method of claim 58, said friction facing material including a plurality of warp yarns positioned in substantially parallel relationship to each other and a plurality of fill yarns woven over and under said warp  
5 yarns to form said texture.

65. The method of claim 64, further comprising the step of tensioning said warp yarns greater than said fill yarns.

66. The method of claim 58, said friction facing material including a plurality of yarns positioned in substantially parallel relationship to each other attached to a layer of scrim.

67. The method of claim 66, wherein said yarns are fill yarns.

68. The method of claim 66, wherein said yarns are warp yarns.

69. A material, comprising:  
    (a) a plurality of first yarns; and  
    (b) a plurality of second yarns woven with  
5       said plurality of first yarns to form a  
       predetermined channel arrangement in order  
       to control fluid flow.

70. The material of claim 69, wherein said first yarns are tensioned greater than said second yarns.

-32-

71. The material of claim 69,  
wherein said second yarns are woven over a plurality of  
adjacent first yarns and under at least one less of said  
first yarns in alternating fashion, wherein a surface  
5 area of said plateaus is maximized.

72. The material of claim 69, said first and second  
yarns being comprised of a material selected from the  
group consisting of fiberglass, silicon carbide, copper,  
ceramic, Kevlar, carbon and asbestos.

73. The material of claim 69,  
wherein said first and second yarns are woven in a  
pattern selected from the group consisting of plain,  
crowfoot satin, 2 x 2 basket, 5 HS, 8 HS, Leno, 2/2  
5 twill, 2/1 twill, non-crimp,  $\pm 45^\circ$  plain,  $\pm 45^\circ$  8 HS, and  
 $\pm 45^\circ$  crowfoot satin.

74. The material of claim 69, said texture having a  
plurality of layers.

75. The material of claim 74, further comprising a  
plurality of internal cooling vents therein.

76. The material of claim 69, wherein said first  
yarns are fill yarns and said second yarns are warp  
yarns.

77. The material of claim 76, wherein said warp  
yarns include a first set and a second set, said first  
and second set of warp yarns being woven with said fill  
yarns substantially  $90^\circ$  out of phase.

-33-

78. The material of claim 69, wherein said first yarns are warp yarns and said second yarns are fill yarns.

79. The material of claim 78, wherein said fill yarns include a first set and a second set, said first and second set of fill yarns being woven with said warp yarns substantially 90° out of phase.

80. A material having a texture with channels of a specified pattern formed therein, comprising:

- (a) a plurality of yarns positioned adjacent to each other; and
- 5 (b) a layer of scrim to which said yarns are attached.

81. The material of claim 80, wherein said yarns are substantially linear.

82. The material of claim 80, wherein said scrim layer is saturated with adhesive, whereby said yarns are attached to said scrim and said scrim is attachable to a friction surface.

83. The material of claim 80, further comprising a layer of adhesive laminated on each side of said scrim.

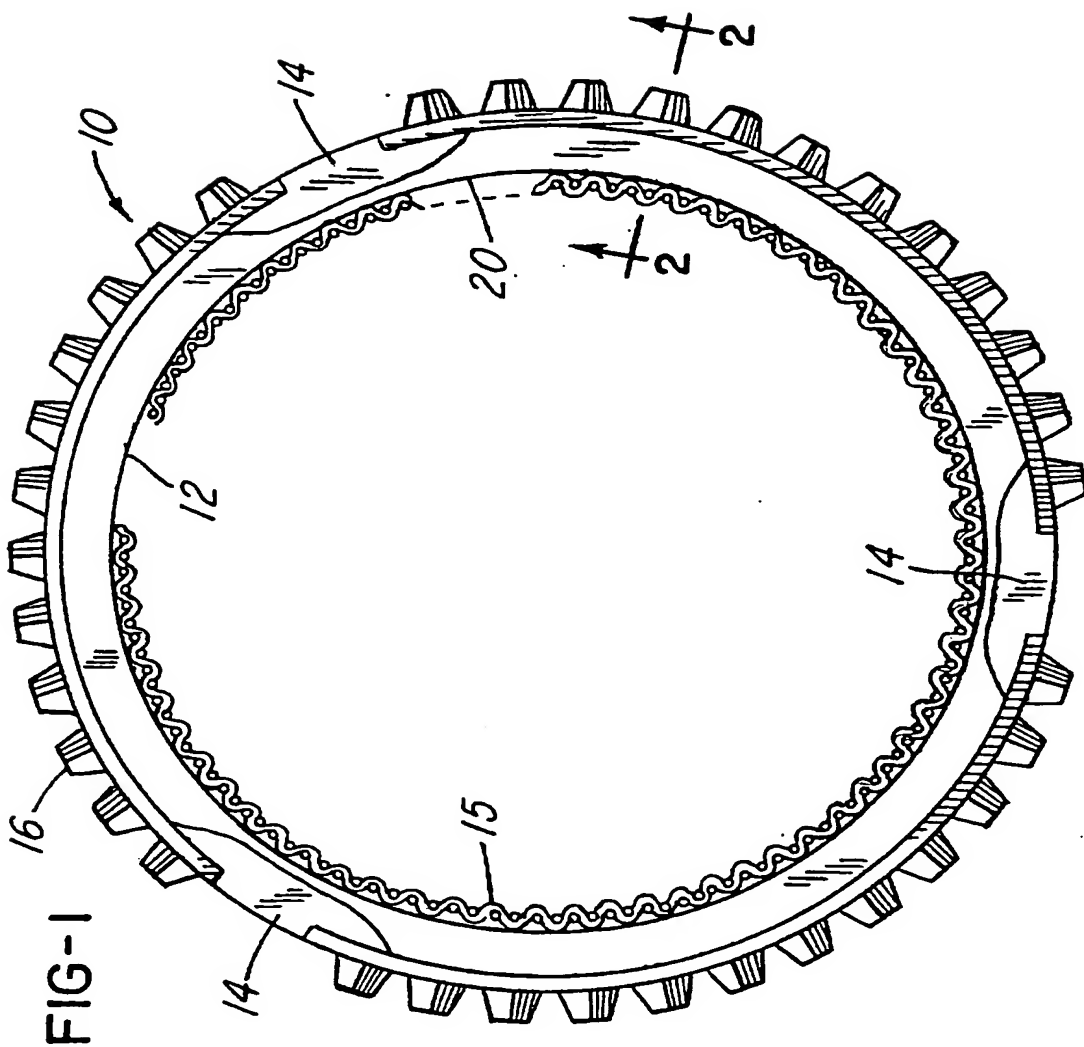
84. The material of claim 80, wherein said yarns are fill yarns.

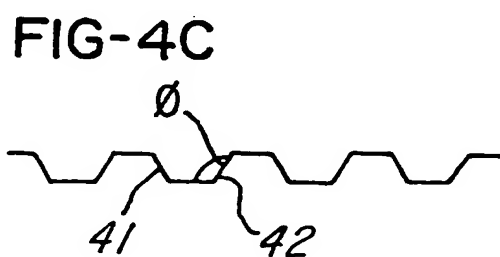
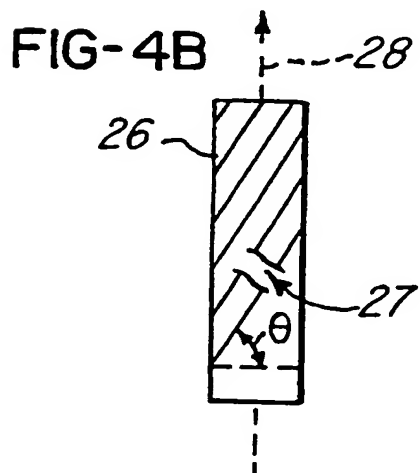
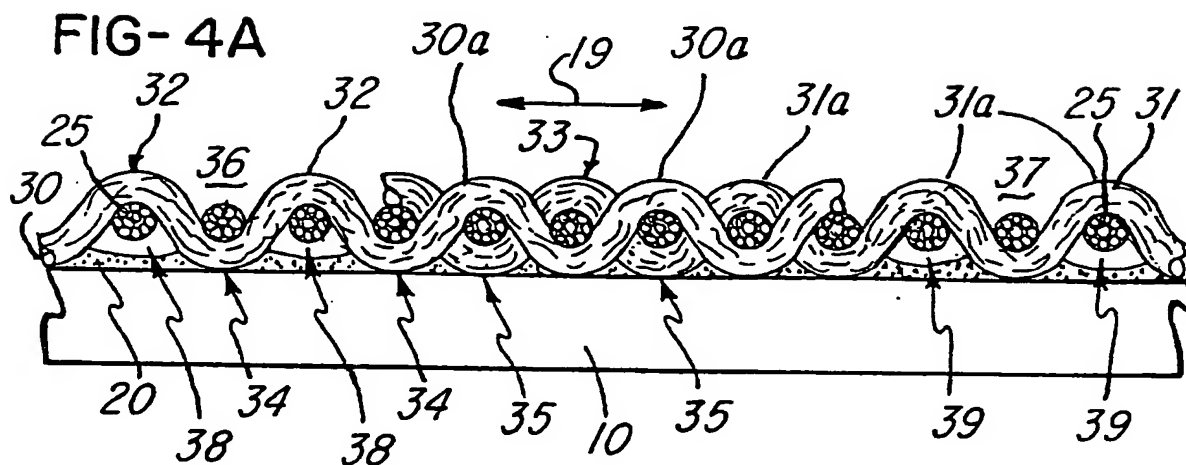
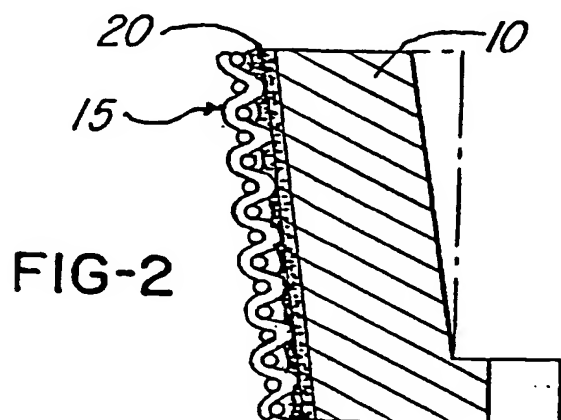
85. The material of claim 80, wherein said yarns are warp yarns.

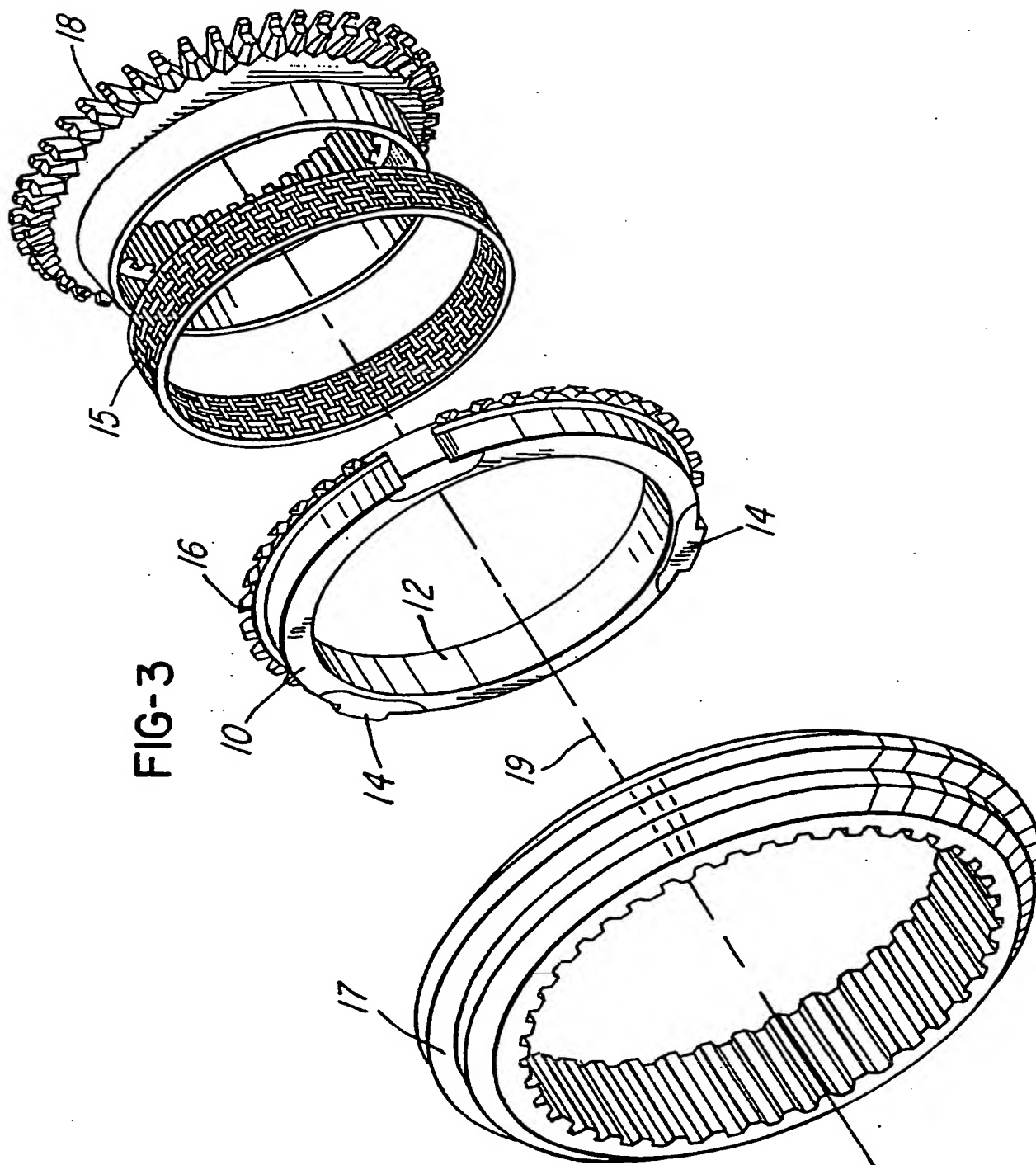
-34-

86. A method of controlling fluid flow between a first area and a second area in an assembly having at least a portion thereof situated between said first and second areas, comprising the steps of:

- 5           (a) arranging a plurality of yarns in a pattern which defines at least one channel; and
- (b) mounting said yarns on said portion.







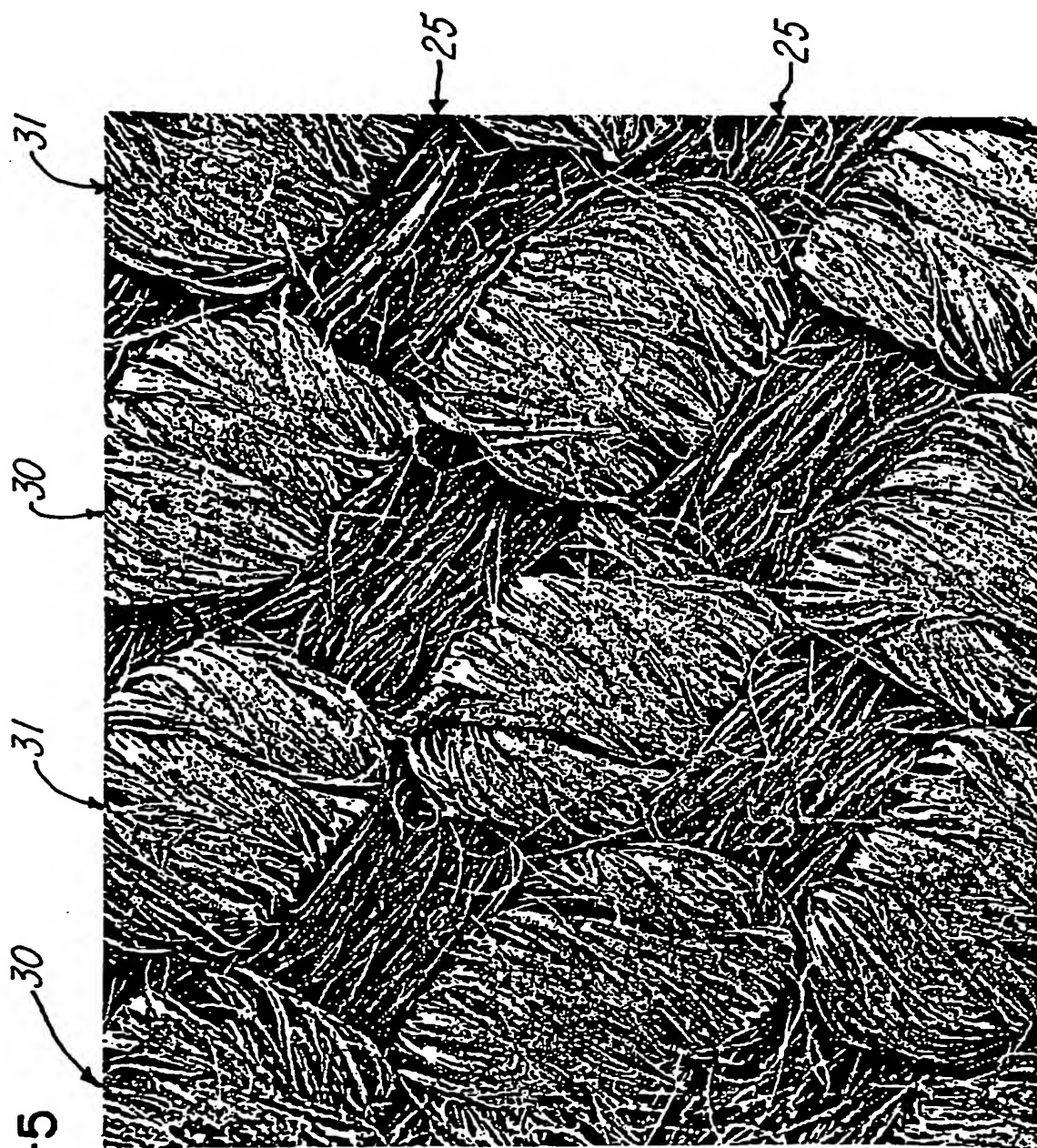
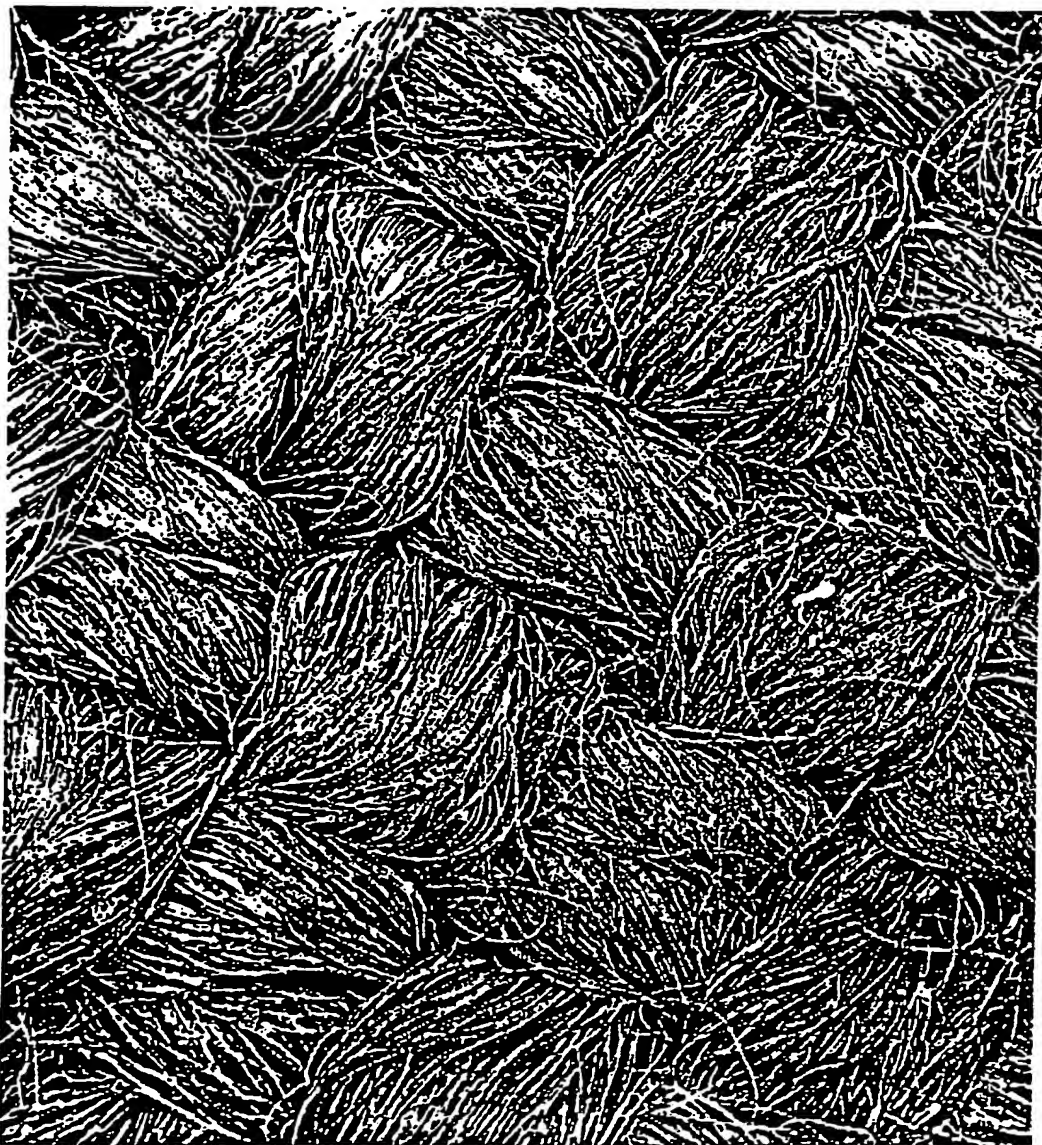


FIG-5

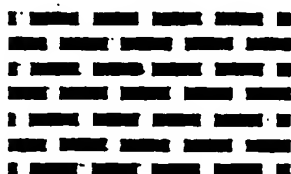


FIG-6  
(PRIOR ART)

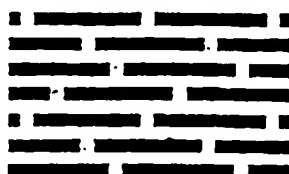


## FIG-7

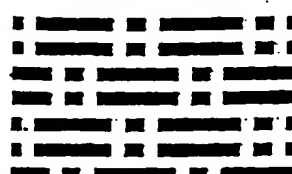
Plain



Crowfoot Satin



2x2 Basket



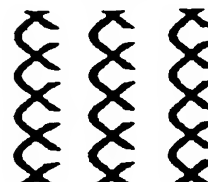
5HS



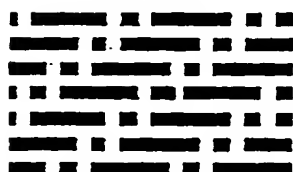
8HS



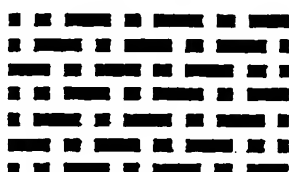
Leno



2/2 Twill



2/1 Twill



Non-Crimp

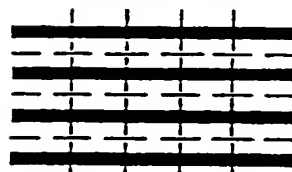
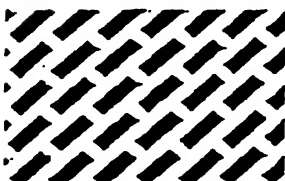
 $\pm 45^\circ$  Plain $\pm 45^\circ$  8HS $\pm 45^\circ$  Crowfoot Satin

FIG-8

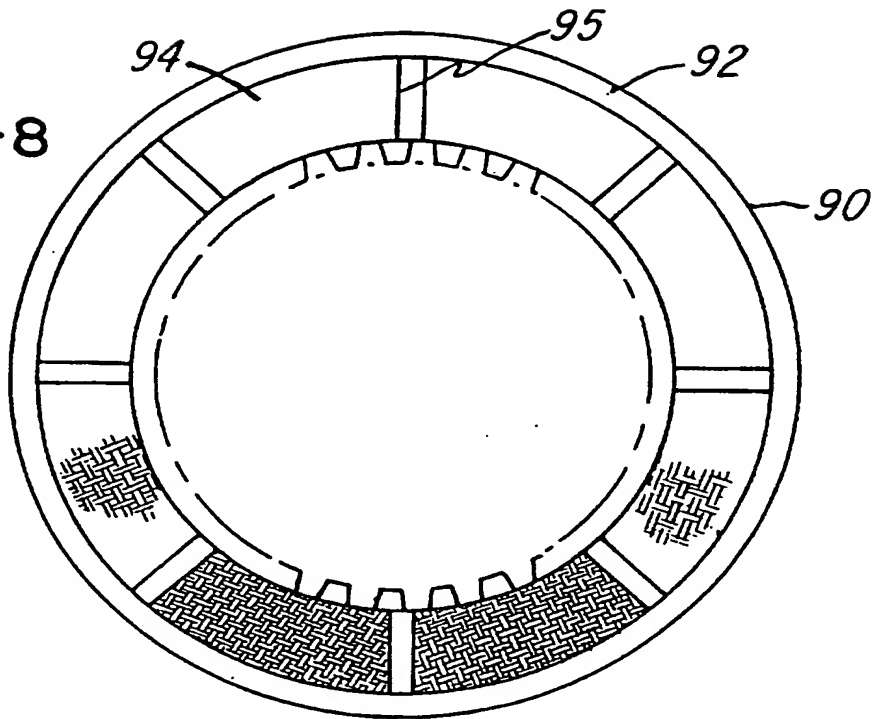


FIG-9

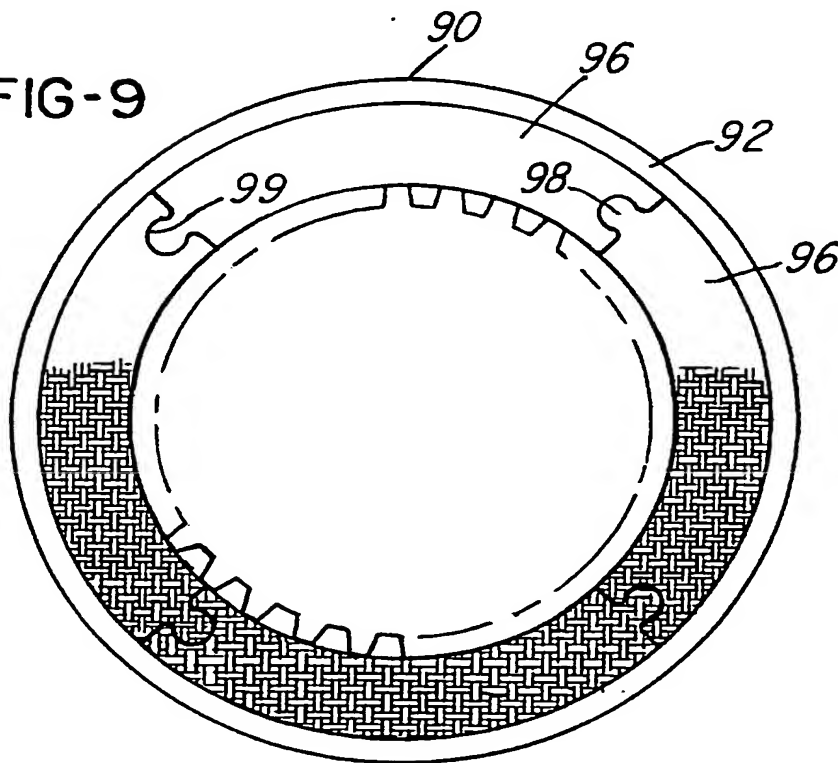


FIG-10

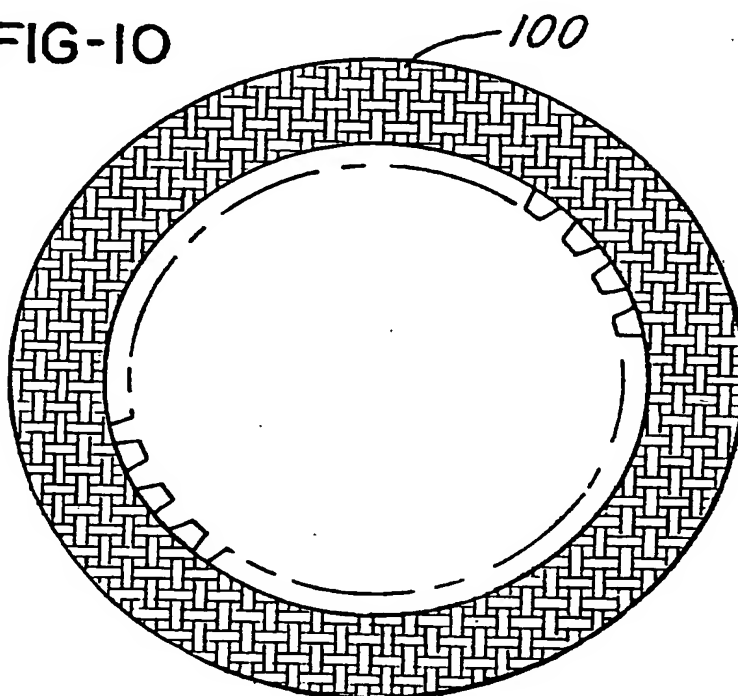


FIG-11

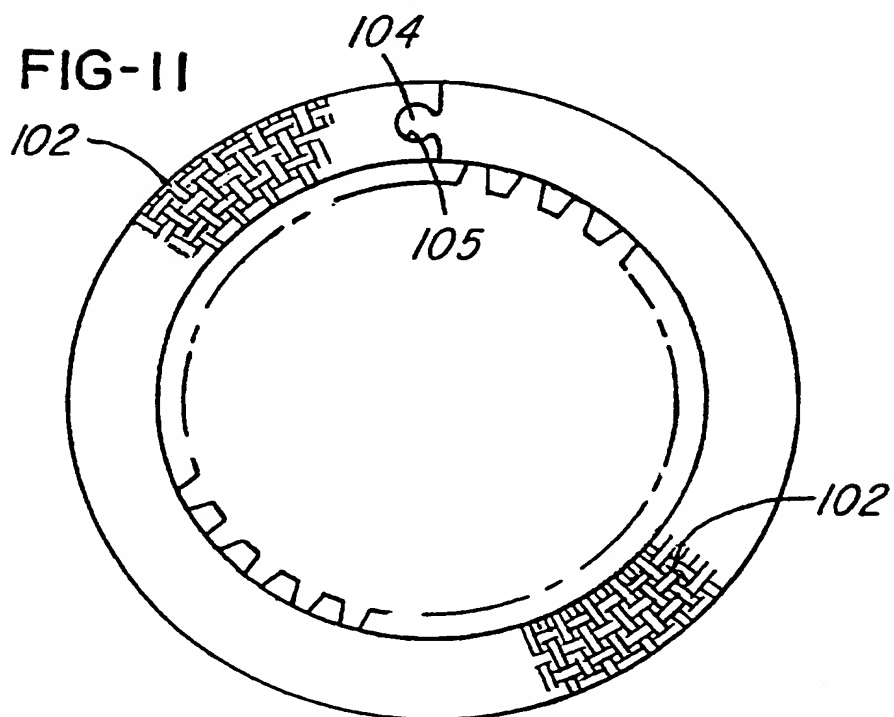


FIG-12A

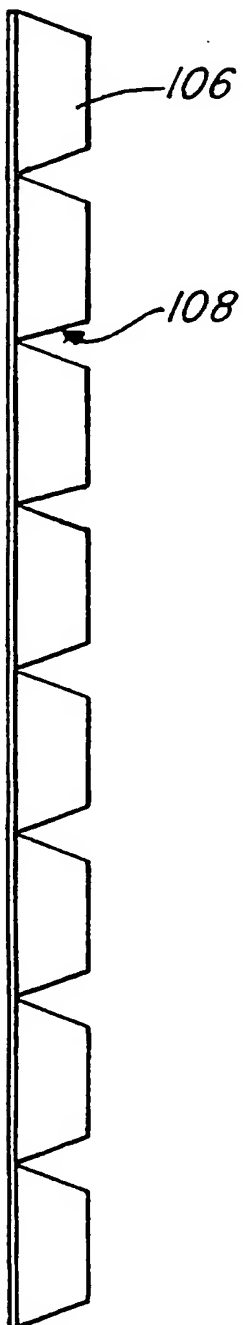
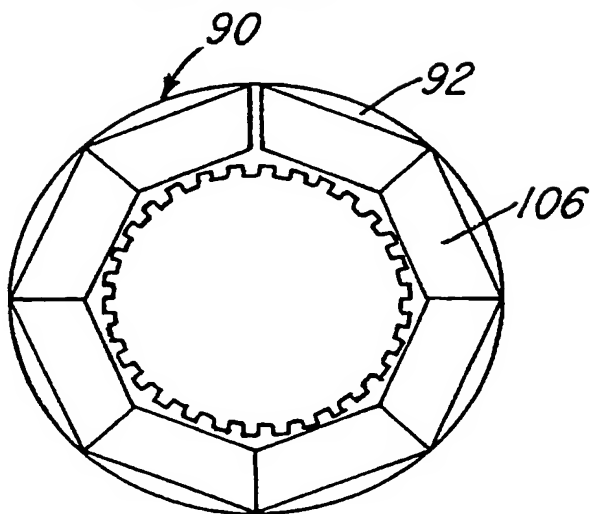


FIG-12B



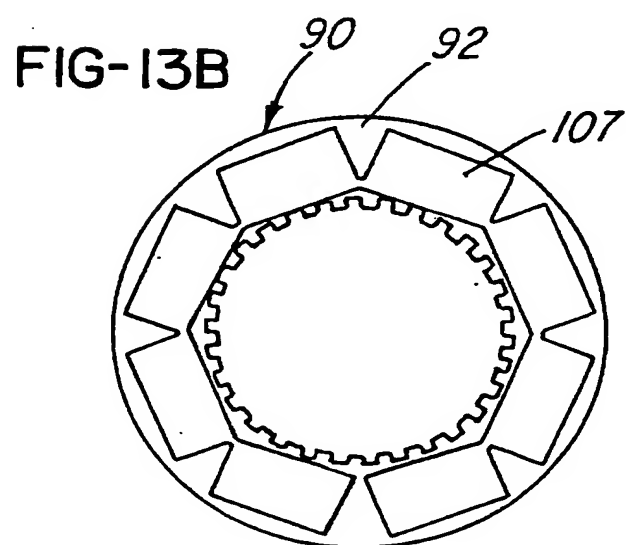


FIG-13A



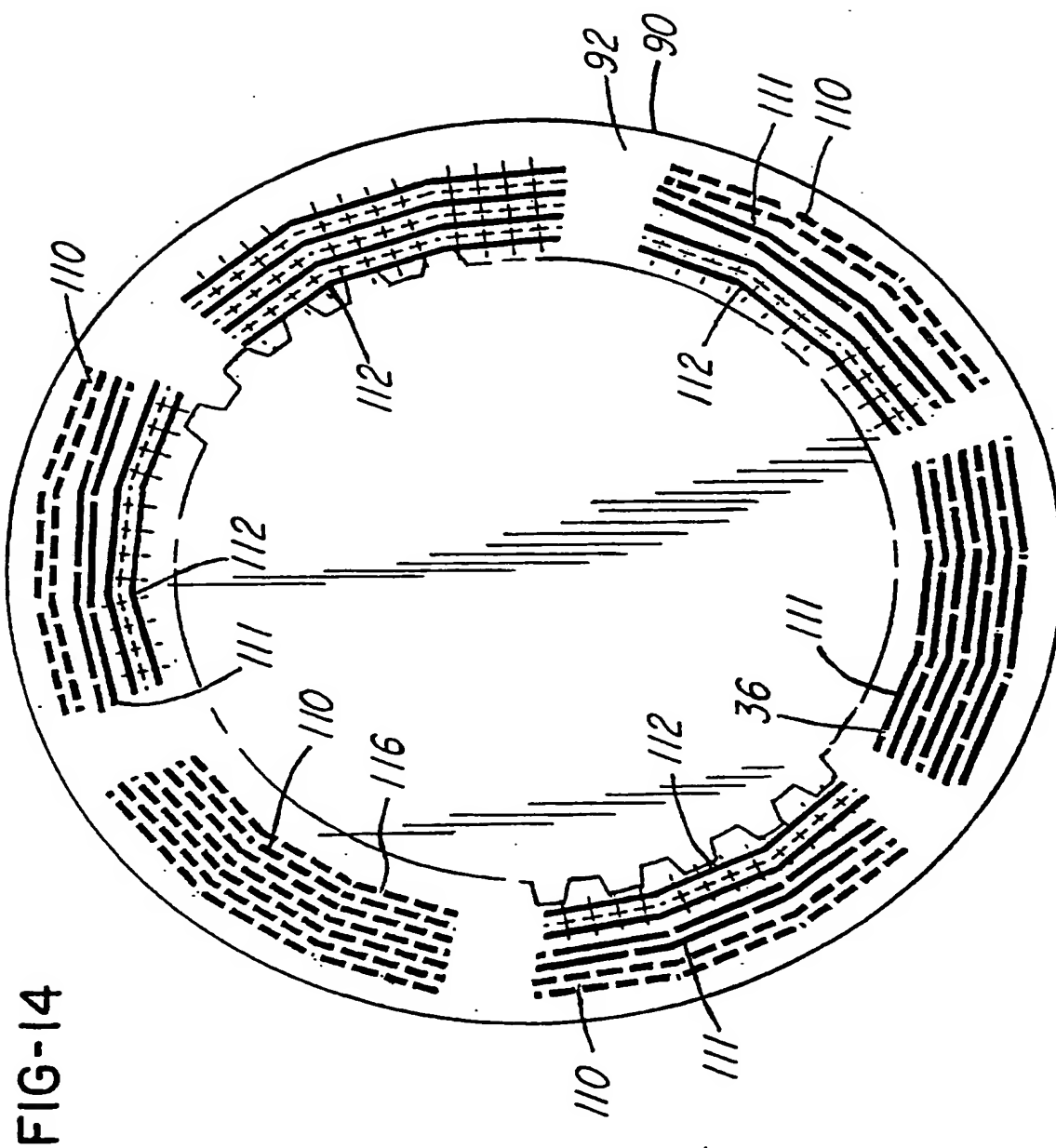


FIG-15

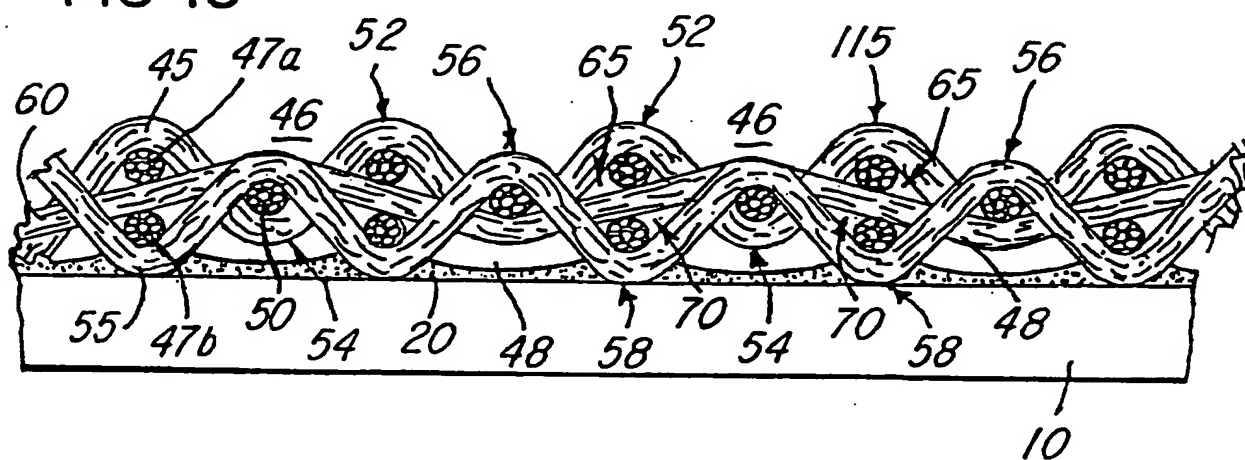
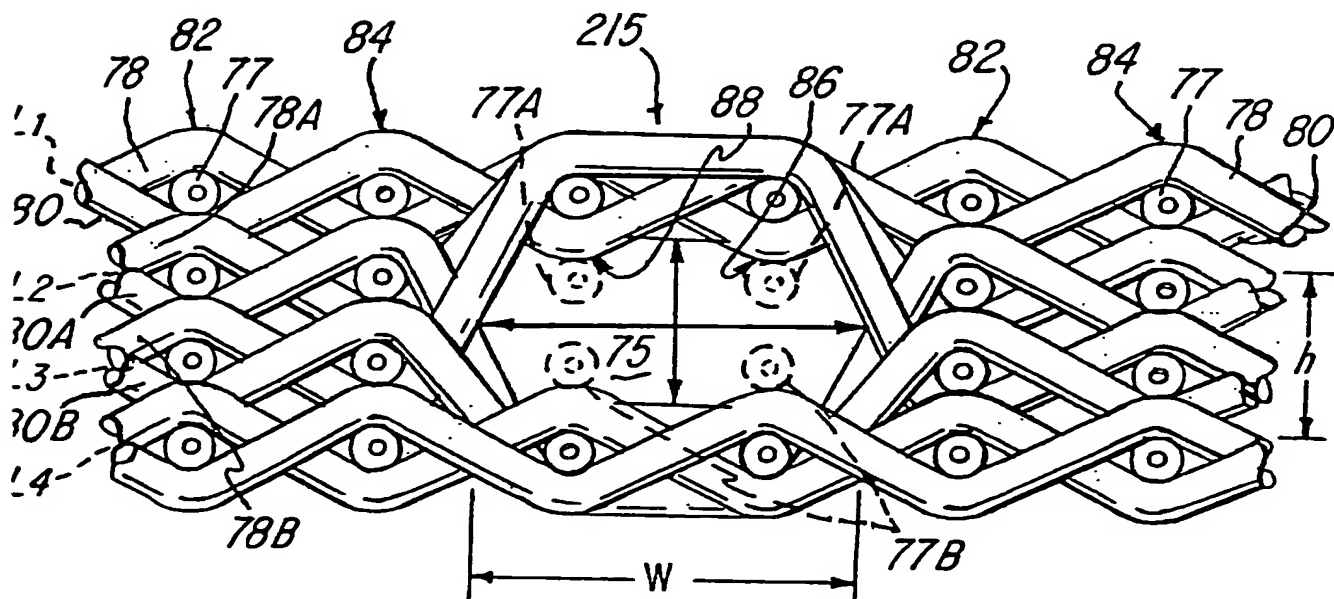
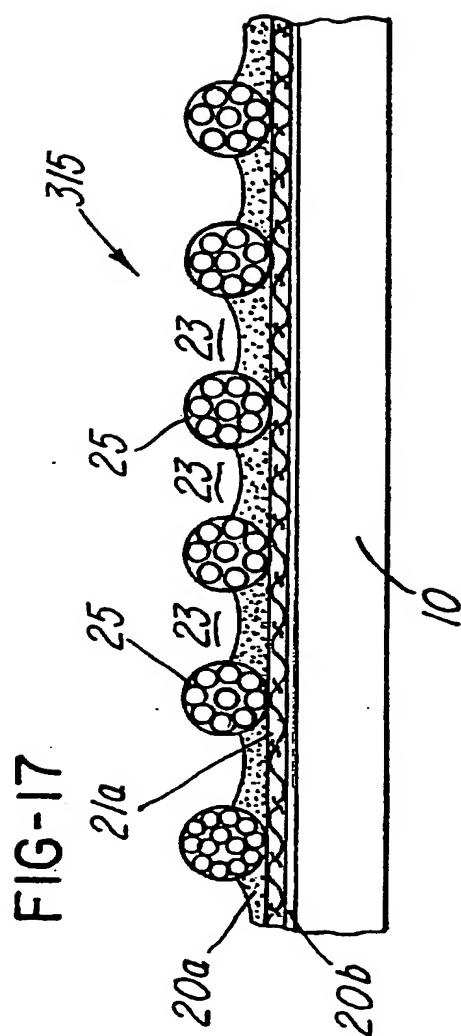


FIG-16





13/13



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/12489

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F16D 13/72, 65/78, 69/02; B32B 7/00, 31/00; D03D 15/00

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 192/107M, 113.3; 428/245, 257, 268, 273, 289, 408, 902; 156/148, 155, 261, 264, 265, 299; 139/383R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
192/107R, 113.2, 113.22, 113.34, 113.36; 188/251A; 139/389Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
NONE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 1,682,198 (Sitton) 28 August 1928, See Figure 1 and page 1, lines 3-5 and 42-45.	69, 73, 74, 86
X	US, A, 1,860,147 (Hadley) 24 May 1932, See Figures 1-4 and page 1, lines 43-57, 81-86 and 95-96.	1, 4, 5, 10, 15, 16, 18, 20, 25, 27, 32-35, 38, 40, 58-68, 69, 73-79, 86
X	US, A, 2,307,814 (Walters) 12 January 1943, See Figures 1 and 3 and page 1, right-hand column, lines 18-40.	1-5, 7, 10, 12, 14-23, 43, 46- 48

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

01 FEBRUARY 1996

Date of mailing of the international search report

01 MAR 1996

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Authorized officer

RICHARD M. LORENCE

Facsimile No. (703) 305-3230

Telephone No. (703) 308-2168

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/12489

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,291,794 (Bauer) 29 September 1981, See Figures 1-4 and column 6, line 25 to column 7, line 48.	1-20, 25-33, 35,40, 43-48, 51, 58-86
X — Y	US, A, 5,221,401 (Genise) 22 June 1993, See Figures 9-11 and column 7, line 62 to column 8, line 16.	43-49, 53- 55 — 50
Y	US, A, 4,260,047 (Nels) 07 April 1981, See Figures 3-6 and column 1, lines 54-62.	50

**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/US95/12489

**A. CLASSIFICATION OF SUBJECT MATTER:**

**US CL :**

192/107M, 113.3; 428/245, 257, 268, 273, 289, 408, 902; 156/148, 155, 261, 264, 265, 299; 139/383R

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**